

For purposes of comparison the minimum temperatures of the last severe frost periods are also given. Data for Lakeside and San Diego are included, although not in the valley. The records at Los Angeles and San Diego are made at the top of tall city buildings and therefore do not truly represent conditions in the orchards. The readings are probably 10° higher than if made in the fields.

It is evident that temperatures were fully as low as during the frost period of December 19, 1909. The damage, however, was much less.

In the following extracts of letters received at this office, unequivocal evidence of the value of the protective devices may be found. It should be explained that the Limoneira Ranch is located on the northern side of the range and that the general air drainage is different from that of the San Gabriel Valley. A report from the official in charge of the local office of the Weather Bureau at Fresno is also given; but a detailed discussion of the conditions in the Porterville section and also in the northern citrus fruit belt must be omitted.

Mr. Edwin R. Sorver, special meteorological observer, Pasadena, Cal., states:

There was very little damage done in the vicinity of Pasadena, except to flowers and tender plants, by the frost. The new growth of citrus trees was nipped in quite a few instances and in some places ice formed one-half inch thick; but on the whole the damage done, especially to the citrus fruit, was a very, very small per cent.

Mr. A. F. Call, Corona, Cal., states:

The frost warning sent me about 4 p. m. December 25 enabled me to get ready in some orchards not then prepared and enabled me to save crops worth at least \$10,000. Where smudging was properly done it was a complete success; but poor work or inefficient preparation has led many to believe it does no good.

I find a great difference in readings, which I think is largely due to the locations of the thermometers, difference in height from the ground, or to slight elevations or depressions from normal contours, or some protection from buildings or trees.

The mornings of the 24th and 25th were not cold here; about 32° in exposed places. All day of the 25th it stood about 50°. By 10.30 p. m. the temperature dropped to 28° and at 1 a. m. of the 26th it had dropped to 22° and by 4 a. m. to 20°, remaining at that until 7 a. m. The temperature was almost uniform over the slope, the 1,000-foot level showing as cold as the 600-foot level.

The cold wave came in from the southeast, down the Temescal Canyon, and moved westward across the mesa at the rate of a mile an hour. Smudging was only done by a few large growers, covering about 200 acres and when thorough work was done was very effective, saving practically all the young lemons.

The smoke from smudged orchards saved a great area of oranges in the neighborhood of each orchard smudged, but was not sufficient to protect lemons to any great extent except in the immediate vicinity of the fires.

A thermometer on the ground read 5° to 6° colder than one 2 feet above the ground.

The only effective smudging here was in the use of slop distillate in 2-gallon pots, set one to the tree, lighting the first half early and the second half toward morning. It is better and much safer to have double the number in alternate rows, so that one to the tree can be used in the morning.

With 80 pots to the acre, burning free—i. e., without soot collectors or covers—the temperature can be raised on a still night 8° or 9° in an orchard of large trees.

Mr. W. E. Bonnett, local forecaster, Fresno, states:

Although temperature conditions in the floor of the San Joaquin Valley were extreme during December, there has been no great damage in the foothill section. At Fresno oranges and lemons were repeatedly frozen on the trees beginning with December 18; but these fruits are not commercially grown and the monetary loss is small. These trees are now turning quite brown and many of the leaves will drop off.

This cold period was the most prolonged and most severe since December, 1897.

Mr. C. C. Teague, manager of the Limoneira Co., states:

On the night of December 24 the temperature on our ranch dropped as low as 23°. We immediately fired all of our oil pots and raised the temperature to 34° \* \* \*. Our experience during the last cold spell convinced us more than ever of the necessity and efficiency of adequate frost protection equipment. The cold portions of our property are equipped with 112 coal baskets and 56 2-gallon Bolton heaters to the acre. We have come to believe that it is very important that one begin firing early in the night before the heat held by the ground and trees has been entirely lost; and our practice has been to begin firing at the first indication of ice on the trees in the most exposed portions of the grove. We feel convinced that we can handle successfully a temperature of 20° or lower for many hours.

It is our belief that if the orange districts where the damage was so great had been as thoroughly equipped as we are and had this equipment been intelligently handled there would have been practically no damage.

Other portions of Mr. Teague's letter, are covered in the report of Mr. Clarence H. Matson, in the following extract from the Pacific Rural Press of January 13:

EXTRACT FROM THE PACIFIC RURAL PRESS, JANUARY 13.

By CLARENCE H. MATSON.

Although the temperature fell dangerously near to the 20° point, C. C. Teague, manager of the great Limoneira Ranch, near Santa Paula, absolutely saved his lemon orchards from damage by frost all through the recent cold spell. Mr. Teague says that not only the fruit, but also the young, tender growth on the trees, show no effects of the frost. Mr. Teague is among the most successful lemon growers in California. He makes a specialty of this branch of the citrus industry and has probably made a more thorough study of lemon growing in all its phases than any other man in the world. His opinions are usually the last word on lemons. In the cold spell, which included holiday week, he proved beyond a doubt the advantages of smudging as a means of frost prevention. He smudged the 225 acres of lemons on the Limoneira Ranch 12 nights out of 14, bringing the fruit through without damage, while groves that were not smudged were badly frosted.

On 200 acres of these groves which are the more liable to frost Mr. Teague had 112 ordinary wire coal baskets and 56 2-gallon distillate burners to each acre. The remaining 25 acres were higher, and on them he used less equipment. The coal baskets are part of old equipment for frost protection, but the distillate burners are comparatively new. They proved very effective, however, and Mr. Teague thinks that if the burners were used exclusively, 100 to an acre would be sufficient, or approximately one to every tree.

On the coldest night of the cold spell the temperature got down to 23° before the smudges were started, yet the burners immediately raised it above freezing point, and it was maintained there. This made a rise of about 11°, as thermometers in the surrounding region kept falling, indicating that the higher temperature in the Limoneira groves was due to the smudging. In some places the mercury went down to 19°.

In the 12 nights that the smudge pots were kept burning nearly 21,000 coal-basket lightings were made, and 50,500 oil-burner lightings at a total cost for fuel and labor amounting to \$4,700. This was about \$1.75 per acre for each night, or less than 2 cents per tree.

The fuel used in the oil burners was slop distillate of from 23 to 28 gravity, and costing from 85 cents to \$1 a barrel. An oil pot will burn about nine hours.

In order to be ready to smudge on short notice, Mr. Teague has a cement reservoir for distillate, holding 100,000 gallons. The oil is pumped into tank wagons with a small centrifugal pump capable of filling a wagon in three minutes. The wagons hold 430 gallons each.

There are no hard and fast rules by which a grower can be guided as to when smudging is necessary, Mr. Teague says, as conditions of moisture and air currents have much to do with it. Sometimes ice will begin to form on the fruit when the temperature is only down to 30°, while at other times the mercury will fall to 26° before causing ice. Mr. Teague's instructions to his men are to watch the lowest place in the groves, and as soon as ice begins to appear on the trees, to start the smudge pots.

It is much better to start them before the temperature gets low, rather than to wait until the freeze begins and then thaw the fruit. Not only is more heat necessary to raise the temperature after it once goes down

than is required to keep it up before it goes low, but if the fruit is once frosted it is necessary to keep the smudges going after the sun comes up in the morning in order to keep a smoke over the groves, so that the sun will not make the thaw too sudden, and thus break down the fruit cells.

Both the authorities of the College of Agriculture of the University of California and the Federal officials, through the Weather Bureau, will make a study of methods of frost prevention. Immediately following the recent cold spell, G. Harold Powell, secretary and manager of the Citrus Protective League, took the matter up with officials of the Weather Bureau and with the College of Agriculture, and authoritative data probably will be compiled which will be of great value to citrus growers in the future.

Comparatively little has been done along that line in the past, and each grower has been guided largely by his own experience and such information as he has been able to gather for himself; so that a definite scientific study of frost-fighting methods will be of much importance.

It is also planned to have the Weather Bureau undertake a special service throughout the citrus belt, if possible, studying particularly the effect of air currents and moisture, as well as temperature, in their relation to damage by frost.

#### NOTES ON FROST AT SAN DIEGO DURING DECEMBER, 1911.

Christmas day was unusually cold in San Diego, heavy frost with ice in exposed places occurring generally about sunrise. The maximum temperature of the day was much lower than usual, the highest, 54°, being registered at 3 p. m. The lowest temperature of the season, 35.6°, occurred at 7 o'clock on the morning of the 26th. Tender vegetation was frozen in the lower parts of the city, but on the higher levels, where there was good air drainage, no damage occurred. Countless poinsetta blossoms through the city and in surrounding suburbs escaped injury. In the orchards the tender growth of lemon and orange trees was blackened, and olives, where grown in the lowlands, were frosted. Light frost only occurred on the 27th.—*Ford A. Carpenter, local forecaster.*